A Nonlinear Optical Coherence Tomography System for Biomolecular Detection and Intervention

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Biomolecular Systems Research Program

Objective

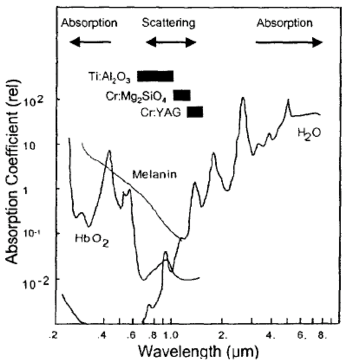

Figure 1. Plot illustrating the "biological window" in tissue for near-infrared wavelengths. Between 750 nm and 1300 nm, optical attenuation is dominated by scattering. The wavelength range for optical sources, including titanium:sapphire ($Ti:Al_2O_3$) is shown.

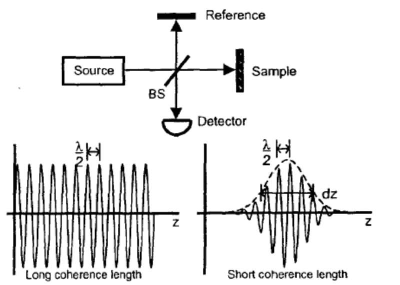

Figure 2. Schematic of low-coherence interferometry. The use of a short coherence length light source enables localization of the backreflection from the sample. The coherence length (dz) defines the axial OCT imaging resolution.

Description

We propose the development of a new instrument that we call the Biomolecular Laser Imaging and Therapeutic System (BLITS). BLITS combines and extends several imaging technologies, including Optical Coherence Tomography (OCT), OCT spectroscopic, imaging, and Coherent Anti-Stokes Raman Scattering (CARS) spectroscopy, to Produce a versatile system capable of noninvasively measuring Micron-scale structure and molecular composition of tissues.

BLITS is based on OCT, an imaging sensor that measures micron-Scale tissue structure *in vivo*.

Innovative Claims/NASA Significance

The Biomolecular Laser Imaging and Therapeutic System (BLITS) will provide an innovative, integrated platform offering diagnostic flexibility, on-line treatment capability, and real-time monitoring. Unlike other noninvasive imaging modalities, such as ultrasound or magnetic resonance imaging, OCT provides micron-scale resolution of cellular and sub-cellular structural features at real-time acquisition rates. Unlike the ionizing radiation used in x-ray computed tomography and PETBPECT, tissues are imaged with low-power near-infrared radiation which poses little to no health risk. Unlike laser-scanning confocal and multi-photon microscopy, no exogenous agents are required to provide image contrast. Using semiconductor and solid-state laser oscillators, the apparatus can be extremely compact, reliable, and turn-key.

The combination of CARS and OCT in BLITS adds molecular and spatial discrimination capabilities not found elsewhere.

Plans

Year/Quarter	Y1 Q1	Y1 Q2	Y1 Q3	Y1 Q4
AIM 1	(1.1) Construct high bandwidth sources		(1.3) Demonstrate high-resolution OCT	
AIM2		(2.1) Construct tissue phantoms		(2.1) Demonstrate SOCT with tissue phantoms
AIM 3				
Year/Quarter	**Y2 Q1**	**Y2 Q2**	**Y2 Q3**	**Y2 Q4**
AIM 1	(1.2) Construction of regen/OCT system			(1.3) Demonstrate regen/OCT imaging and tissue ablation
AIM2				
AIM 3	(3.1) Demonstrate CARS OCT tissue phantoms	(3.1) Build pulse shaper for CARS OCT		
Year/Quarter	**Y3 Q1**	**Y3 Q2**	**Y3 Q3**	**Y3 Q4**
AIM 1				
AIM2		(2.2) Prepare hamster carcinoma model	(2.2) Spectroscopic imaging of hamster model	(2.2) Analyze spectra for correlative signatures of oncogenesis
AIM 3	(3.1) Demonstrate CARS OCT on tissue phantoms		(3.2) CARS OCT imaging of hamster model	(3.2) Analyze molecular species density for correlative signatures of oncogenesis